needed to precisely locate sedimentary deposits of the right mineralogy (i.e., rock types most favorable for preserving a fossil record of past life) in order to effectively plan rover operations. The 2001 MGS orbiter is presently slated to carry a high-resolution, mid-infrared mapping spectrometer called THEMIS which will be capable of attaining this resolution at selected high priority sites.

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Molecular Biomarkers in Living Stromatolites

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Stromatolites, among the most common fossils in the geologic record, are defined as organo-sedimentary structures formed by sediment trapping and binding or by mineral precipitation (or both) of microbial communities living in shallow water environments. The microfossil record in stromatolites traces Earth's history since the oldest life, over 3.5 billion years ago. During most of this time, microbial life has dominated Earth, and has been responsible for transforming the primitive anaerobic environments of early Earth, devoid of free molecular oxygen, to the modern aerobic world that supports contemporary biology. Microbial mats are "living" stromatolites, modern day analogs that provide an opportunity (a window to the past) to study the way ancient microbial communities lived and evolved. Today, a variety of these "living" analogs, representing a range of environmental and organismal parameters, are available for study throughout the world. For the most part, the dominate members of recent mats are oxygenic photosynthetic bacteria, the cyanobacteria. The evolution of oxygen-producing photosynthesis within the cyanobacteria heralded the beginnings of our modern aerobic world, and the timing of this event is of particular interest in attempts to understand the process of Earth's evolution.

A variety of stable organic compounds, generally referred to as chemical fossils or biomarkers, have been extracted from stromatolites. Indigenous fossil biomarkers can provide clues to the identity of the original mat-building community and provide insights into the paleoenvironment in which this community existed. The challenge is to understand the link between such molecular fossils and their "living" counterparts, the biomarker molecules synthesized by contemporary mat-building bacteria, and then to apply this information to the study of contemporary microbial mats. Efforts at Ames Research Center are focused on a type of columnar (or conical) stromatolite, the Conophyton, which is one of the most distinctive groups of Precambrian stromatolites. A "living" Conophyton analog is currently forming as the result of silicification of a mat constructed by a fine filamentous cyano-bacterium called *Phormidium* in hot springs located in Yellowstone National Park.

The study began by isolating a variety of *Phormidium* cyanobacteria from columnar, microbial mats found in Yellowstone. Two important types of organic molecules have been identified in these cyanobacteria: a group of branched alkanes having 17 to 20 carbons (C_{17}–C_{20}), and hopanoids, a highly cyclized C_{30} molecule (see figure). Both methylalkanes and hopanes are excellent biomarkers for cyanobacteria, are resistant to biodegradation, and are presently known to be the oldest biomarkers dating to Proterozoic rocks 1.7 billion years old. Interest at Ames is in the processes involved in the deposition or degradation of organic material during early mineralization of microbial mats, particularly as this relates to the potential for preserving biomarkers such as branched alkanes and hopanes, which are thought to be more highly resistant to microbial degradation.

In order to relate biomarker analysis of *Phormidium* cultures to their natural environment, the study at Ames is concerned with a type of submerged, columnar *Phormidium* mat widely prevalent in the terraced pools found in the Midway Geyser Basin in Yellowstone. As the pools dry up, the mat surface is gradually covered with a silica layer.

Organic analysis of the distribution of branched alkanes and hopanoids in the submerged and silicifying *Phormidium* mats shows that these cyanobacterial biomarkers dominate the surface photic zones, and that the relative amount of branched alkanes increases in the silicified mat surface. Surprisingly, another cyanobacterial biomarker, esterified polyunsaturated fatty acid (PFA), which is considered a measure of the number of viable cyanobacteria present, was at comparable levels in the surface zones of both the submerged and exposed mats. The cyanobacteria in the top layer of this silicifying, heavily encrusted mat were still very much alive, although an increase in the amount of PFA in the exposed mat does suggest an adaptive response.

There are, however, clear differences in biomarker preservation in the layers below the top photic zone. The relative compositions of the branched alkanes and hopanoids in the submerged mat are actually higher in the lower layers than in the top layer; in the exposed mat, these compounds are greatly reduced in the lower layer relative to the top photic zones of either submerged or silicified types. These changes in lipid biomarker composition suggest an adapting cellular response during the early diagenesis of this mat. It will be important to understand how such adaptation relates to further preservation of these biomarker fossils as mineralization and diagenesis continue toward the rock record.

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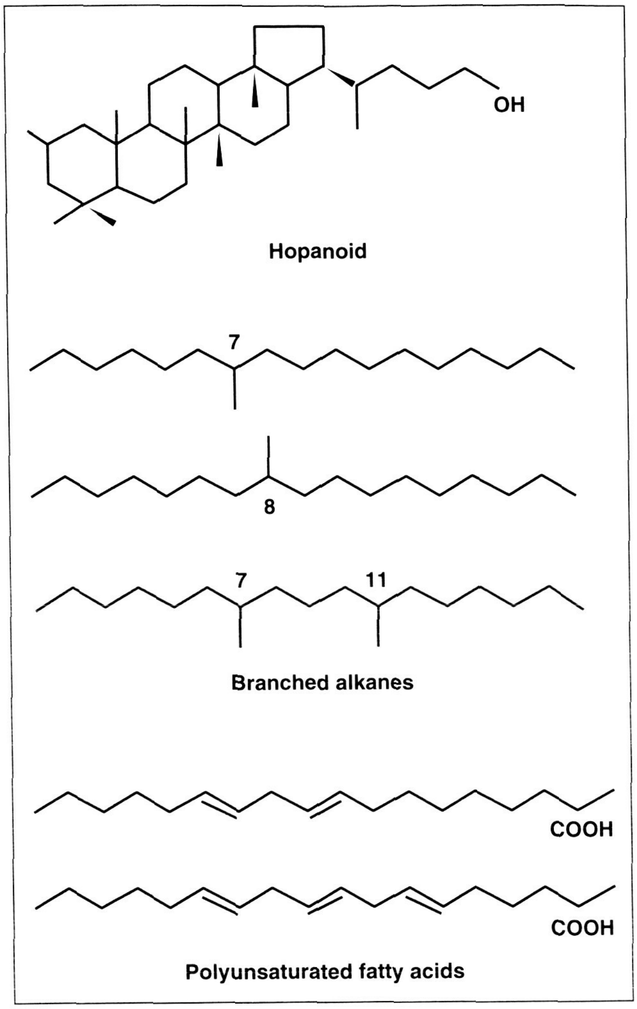

Fig. 1. Molecular biomarkers from Phormidium *cyanobacteria isolated from microbial mats in Yellowstone National Park.*